Review Article

Short Daily and Long-hours Daily Nocturnal Hemodialysis: Methods, Outcomes and Future Directions

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Daily, or quotidian, hemodialysis continues to garner interest worldwide. The two most common forms in use are short daily hemodialysis (hemeral hemodialysis) and daily nocturnal hemodialysis. The currently accepted thrice-weekly dialysis regimen adopted some four decades ago was not designed to provide optimal patient outcomes, but rather to achieve some kind of compromise between adequacy, patient acceptance and economic factors. In the last decade, a number of observational studies have unanimously demonstrated multiple clinical benefits with more frequent dialysis. This paper reviews some important methodologic aspects of quotidian dialysis delivery and the outcomes literature in this field, including economics. [*Hong Kong J Nephrol* 2004;6 (1):14–21]

Key words: quotidian, nocturnal, hemeral, daily, hemodialysis, review

一天一次之血液透析 (quotidian hemodialysis) 可於晝間 (hemeral) 或夜間 (nocturnal) 施行，雖然並非目前主流的血液透析法，但在醫學界中仍持續引起廣泛的與趣。至於目前獲得廣泛應用的一天三次透析，已具有 40 多年的歷史，其目的並非為病人提供最佳的透析效果，而是在透析足夠度、病人接受度、及成本之間取得較佳的平衡。在過去 10 年間，多項觀察性研究已一致證實較頻繁的透析，可為病人提供多方面的臨床效益。本文對一天一次血液透析之施行方式、及實際表現 (包括在經濟學上)，作出了文獻的回顧。

Introduction

Daily, or quotidian, hemodialysis continues to garner interest worldwide. The two most common forms in use are short daily hemodialysis (SDHD), also termed hemeral hemodialysis, and daily nocturnal hemodialysis (DNHD). Although these are the most popular forms in use, hybrids exist as well. Both are commonly used as home-based therapies, even though they can also be administered in dialysis centers.

The currently accepted thrice-weekly dialysis regimen adopted some four decades ago was not designed to provide optimal patient outcomes, but rather to achieve some kind of compromise between adequacy, patient acceptance (i.e. convenience), and economic factors. Unfortunately, this occurred despite clear evidence that there is a strong relationship between patient outcomes and delivered dialysis dose. In the last decade, a number of observational studies have unanimously demonstrated multiple clinical benefits with more frequent dialysis. The greatest barrier to the popularization of quotidian dialysis has been the lack of appropriate funding mechanisms in most developed countries, so it remains largely experimental. Despite this obstacle, there appears to be a growing number of centers wishing to establish their own programs, and the quotidian dialysis community continues to grow. This paper reviews some important methodologic aspects of quotidian dialysis delivery and the outcomes literature in this field, including economics.

A Rationale for Daily Dialysis

Over the last decade, there has been great interest in studying the effect of dialytic dose on patient outcomes.

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This rests on the notion that a greater dialytic dose results in greater solute removal and this, in turn, results in improved patient outcomes. Attempts to increase dose delivery in conventional, thrice-weekly hemodialysis by prolonging treatment time and increasing dialysis efficiency with higher blood flow rates and high-flux membranes did not result in improved overall survival in the HEMO study [1]. Interest has since turned to the effect of increasing dialysis frequency.

The rationale for daily dialysis is best understood by considering the difference in solute removal achieved by delivering the same number of hours of dialysis per week divided over 6 versus 3 days, (e.g. 6 × 2-hour versus 3 × 4-hour treatment sessions). It is known that most of the urea (up to 75% with very high efficiency dialysis membranes) is removed during the first 2 hours of a 4-hour dialysis treatment [2]. This is explained by the fact that the serum urea concentration falls logarithmically over time, and as it falls, the concentration gradient across the dialysis membrane similarly falls, thus limiting the rate of solute removal over time. Indeed, for this reason, the conventional dialysis regimen has been described as "self-extinguishing" [3]. This is largely accounted for by the delay in the diffusion of solutes from various compartments into the blood compartment or solute disequilibrium. This phenomenon accounts for the rebound in solute concentrations that is seen in the post-dialytic period. Its magnitude varies from one solute to another.

The relative benefits of frequent short and long hemodialysis regimens are best illustrated by separately considering the effects of increased dialysis frequency and dialysis time on the removal of various solutes [4]. Small solutes that diffuse easily across compartmental barriers (such as urea) are rapidly removed during dialysis. For the reasons described above, increasing the time on dialysis will not result in much incremental benefit in removing such solutes. Increasing dialysis frequency, however, capitalizes on the fact that more time is spent on dialysis while the blood solute concentrations are high (i.e. in the post-rebound state). In the first few weeks of SDHD, however, there is a progressive fall in the predialysis levels of small solutes until a new steady-state is reached, where overall net solute removal is lower than in the first week. This is the case for solutes such as potassium, H^+, creatinine, and urea [5]. Thus, quotidian hemodialysis results in lower overall time-averaged levels for these solutes over the week, and smaller oscillations in their levels, thus overcoming dialysis "unphysiology" as first described by Kjellstrand et al in the early 1970s [6]. This effect of increased frequency is found with both SDHD and DNHD regimens.

Other low-molecular weight solutes that exhibit a large degree of disequilibrium can also be rapidly cleared from the blood compartment during dialysis. The combination of these characteristics results in a rapid decline in the serum concentration and impedes effective removal of such a solute during dialysis. The prototypic molecule in this group is phosphate [7]. Time is required for inter-compartmental shifting to occur, so this substance is cleared in a time-dependent fashion.

The removal of greater molecular weight solutes (e.g. β_2-microglobulin and other middle molecules) is limited by the inefficiency of their removal from the blood compartment, so disequilibrium becomes less important. For such substances, membrane flux and surface area, as well as time, are the principal determinants of net removal. Longer dialysis therefore offers the added advantage of increased phosphate and middle molecule clearance [8].

Finally, it is also recognized that increased dialysis frequency may result in a reduction in intradialytic fluid gains (provided the daily fluid intake remains constant, which is not always the case). This requires that less volume is removed per treatment session, and should thus facilitate fluid removal. This has obvious benefits for patients with massive fluid gains or other reasons for intradialytic hypotension. Although on the one hand, large ultrafiltration volumes result in greater solute clearance, it is also known that over-hydration and large volume shifts are associated with deleterious effects on cardiovascular health such as promoting left ventricular hypertrophy (LVH).

Dose Quantification in Quotidian Dialysis

The single-pool and equilibrated models (spKt/V and eKt/V, respectively) used for dose quantification in conventional dialysis are not validated for use in frequent dialysis regimens. Because these models do not take dialysis frequency or efficiency into account, they cannot be used to compare conventional with quotidian dialysis regimens. Various models have been designed to measure delivered dose independently of frequency of treatment. These include the continuous equivalent of intermittent clearance derived by Casino and Lopez [9], the normalized Kt/V proposed by Depner [3], and the standard Kt/V (stdKt/V) proposed by Gotch [10]. Suri et al have compared the stdKt/V with various conventional models [11], but no study has yet correlated any of these newer measures with patient outcomes.

Current US National Kidney Foundation – Dialysis Outcomes Quality Initiative guidelines suggest a conventional dialysis dose of 1.2 spKt/V per session or 2.0 stdKt/V per week; these are both equivalent to a daily session eKt/V of 0.38. While maintaining the same weekly hemodialysis time but performing treatments daily, Suri et al found that the weekly stdKt/V increased to about 3. DNHD can provide a higher dose of dialysis

than any other outpatient dialysis modality (spKt/V about 2.0 per daily session or weekly stdKt/V > 5) [12].

Methodology

Patient selection

The primary prerequisite for enrollment in a quotidian dialysis program is patient willingness, coupled with either the ability to perform the dialysis procedure or a willing and able partner. While there may be a tendency to offer quotidian dialysis to younger, healthier patients (with the hope of offering them the best possible outcome), others have used it across all patient groups regardless of comorbidity. Indeed, in a recent study by Ting et al, 42 conventional hemodialysis patients with high levels of comorbidity were switched to SDHD and followed prospectively with respect to quality of life (QOL) and other outcomes [13]. These patients, with an average of four comorbid factors each, showed significant improvements in QOL as measured by a validated kidney disease-specific questionnaire, as well as reductions in erythropoietin (EPO) and antihypertensive medication use. Quotidian dialysis has been used as salvage therapy for patients with refractory problems such as malnutrition, hypertension, heart failure, and metabolic bone disease [14].

Materials and equipment

The technical aspects of quotidian dialysis delivery have been extensively reviewed elsewhere [15], thus only a brief review is presented here. Any dialysis machine suitable for administration of conventional hemodialysis can safely be used for the delivery of SDHD or DNHD, either at home or in-center. However, a number of new machines are currently being developed and evaluated for home quotidian dialysis [16,17]. It is hoped that these will be more user-friendly (automated, self-cleaning) and compact than standard machines. Machines with dual pumps that allow for single-needle vascular access are gaining popularity. These may be particularly useful in slow, long, nocturnal dialysis, where clearance is not compromised by the slower blood flows that they require.

Currently, there are no data to support the use of one kind of dialysis membrane over another in quotidian dialysis. Generally speaking, most centers have used high-flux membranes, and some have even used pediatric membranes [12]. Dialyzer reuse has been described, but has largely been abandoned with the fall in prices of dialysis membranes [18].

Reverse osmosis water purification systems are becoming increasingly compact, and remain the most commonly used form of water treatment in the home dialysis setting. De-ionization is occasionally required, depending on local water quality. Ultrapure dialysate has also been used in some programs and can be considered when a concern about water quality exists [15,19]. While water treatment systems for SDHD can be located in the room where the treatment is performed, noise precludes the use of this setup for patients who perform dialysis while sleeping. Thus, remote installation is preferred.

Dialysis prescription

For SDHD, blood and dialysate flow rates are similar to those used in conventional dialysis. For DNHD, the blood flow can be reduced to 200–300 mL/min and the dialysate flow to 100–300 mL/min.

Dialysate composition for SDHD typically does not change when switching from conventional dialysis. For DNHD, dialysate composition must be individualized, particularly with respect to calcium and phosphate content. A typical composition includes sodium 140 mEq/L, potassium 2 mEq/L, bicarbonate 32 mEq/L, and calcium 3–3.5 mEq/L (1.5–1.75 mmol/L), and usually contains phosphate 1–2 mg/dL (see below).

Commonly, patients receiving DNHD eventually have low predialysis phosphate levels. If this persists after discontinuing phosphate binders and liberalizing dietary phosphate intake, then phosphorus must be added to the dialysate. Preparations such as Fleet Phospho-Soda® and Fleet Enema® (Fleet Pharmaceuticals, Lynchburg, VA, USA) have been used and can be added to either the acid or bicarbonate concentrates by the patient. The ideal dialysate calcium concentration for an individual patient will vary with dietary calcium intake, supplemental calcium (in the form of phosphate binders), vitamin D analog use, and the level of parathyroid gland activity. Occasionally, measurement of pre- and postdialysis total or ionized calcium levels can help identify an ideal calcium concentration. This is discussed in more detail below.

Both SDHD and DNHD may be performed using standard heparin protocols. DNHD cannot be performed without anticoagulation since this would require intermittent flushes of normal saline during the night, but this is feasible in SDHD while the patient is awake.

Vascular access

With few exceptions, vascular access planning for quotidian dialysis patients is the same as for conventional hemodialysis patients. Arteriovenous fistulas are the preferred form, followed by grafts and central venous catheters. The buttonhole technique has gained popularity among quotidian dialysis programs. This involves reusing two out of three needle sites on a rotating basis, with eventual tract formation that allows the use of blunt needles [20]. This has been shown to improve patient comfort and may improve access longevity. The single-needle technique has also been

used in DNHD and offers the potential for improved safety and enhanced access survival.

Safety issues

Many innovations have added to the safety of home quotidian dialysis. For patients using central venous catheters, a modified catheter cap known as the InterLink® system (Baxter Healthcare Corporation, Deerfield, IL, USA) has been used to prevent air embolism.

Special precautions are required for patients dialyzing during sleep. Clam-shell locking boxes have been devised to prevent catheter-tubing connections separating during DNHD. Moisture sensors and enuresis alarms have been used to detect leaks around the machine and around the needle insertion sites, respectively. Finally, live remote monitoring by modem/internet has been used to ensure that patients respond to machine alarms. Monitoring personnel typically contact the patient by telephone when there is a problem. While this technology may be useful in a new program during the learning and development phaes, many experienced programs have abandoned this form of monitoring without any complications thus far.

Outcomes Improved by Quotidian Dialysis

Over the last decade, there has been a growing body of literature demonstrating marked improvements in various intermediate outcomes. These include, but are not limited to, cardiovascular parameters such as LVH and hypertension, anemia management, metabolic bone disease, nutritional indices, and QOL.

Cardiovascular parameters

Numerous studies have established that both SDHD and DNHD result in a rapid reduction in blood pressure. While some of the observed benefits occur within the first 2 weeks of quotidian dialysis therapy, others have noted gradual improvements as long as 1 year after initiation of quotidian dialysis [21]. The number of antihypertensives needed decreases significantly by 50% to 90% [19,22].

The mechanism by which blood pressure control is achieved in quotidian dialysis is likely to be multifactorial. While it has long been presumed that volume control is at the heart of this phenomenon, it has recently become clear that patients undergoing DNHD can experience improvements in blood pressure without necessarily experiencing reductions in extracellular fluid volume as measured by bioelectrical impedance [21]. Recent work by Chan et al found improvements in blood pressure in DNHD-treated subjects in association with reductions in peripheral resistance and in circulating neurohormonal factors including norepinephrine [23].

LVH correlates with mortality in patients on chronic hemodialysis. Volume overload, anemia, and hypertension are known potent stimuli for the development of LVH. Both SDHD and DNHD promote improvements in left ventricular geometry and left ventricular mass [24,25]. These changes have been attributed to improvements in blood pressure control [26] and anemia management [27], though again, neurohormonal factors cannot be excluded. Using a double cross-over design, Buoncristiani et al showed that switching patients from conventional hemodialysis to SDHD and back again resulted in regression of LVH (measured by left ventricular mass index) followed by recurrence on resumption of conventional therapy [28]. The strongest correlate of LVH in this study was extracellular fluid volume, supporting the view that volume is important in promoting LVH in hemodialysis patients. Finally, patients with symptomatic heart failure have benefited from DNHD, both with respect to symptoms and improvements in ejection fraction [29].

Anemia management

The numerous studies reporting outcomes in anemia management in quotidian dialysis have yielded an array of conflicting results. The primary outcomes of interest in this area have been EPO utilization and achievement of recommended hemoglobin targets. Some studies have reported improvements in achieved hemoglobin level with between 30% and 40% reductions in EPO requirements [22,27,30]. In our own reported experience at Humber River Regional Hospital (HRRH), patients receiving DNHD did not initially show any reduction in EPO requirements, but this was seen in association with low ferritin and transferrin saturation [12]. In a subsequent report, we demonstrated that intravenous iron supplementation was required before reductions in EPO requirements could be achieved [19,31]. The London Daily/Nocturnal study failed to show any significant reduction in EPO utilization and attributed this finding to increased blood loss (in the dialysis circuit) in quotidian dialysis subjects [32].

Nutritional indices

Nutritional status impacts substantially on survival in the end-stage renal disease (ESRD) population. Measures such as the protein equivalent of total nitrogen appearance (nPNA), cholesterol, and serum albumin have been shown to predict outcomes, and all are significantly improved by quotidian dialysis. To date, studies assessing nutritional parameters in quotidian dialysis have been small. However, despite this, some interesting observations have been made.

The London Daily/Nocturnal study found increases in albumin and arm muscle area in SDHD subjects, but

not in those undergoing DNHD [33]. Unfortunately, in this small study, two of 10 patients in the DNHD group were particularly sick during the study, and their low albumin levels had a negative impact on the overall group mean. Another small study, however, did find improvements in nPNA as well as cholesterol in DNHD subjects [34]. These changes are attributable to increased appetite, with increased caloric and protein intake. Although amino acid losses in the dialysate are expected to be higher in DNHD [35], total body nitrogen, as measured by *in vivo* neutron activation analysis, was found to remain stable over a 2-year period [36]. In essence, these changes are not surprising, given that anorexia is one of the earliest and most readily treated symptoms improved by more frequent dialysis.

Studies of body composition have shown favorable results in quotidian dialysis patients as well. Bioelectrical impedance has emerged as a convenient, noninvasive and accurate pool for assessing body composition including body-cell and fat-free mass. The bioimpedance parameter known as phase angle (which is related to body-cell mass) is known to correlate positively with survival in dialysis patients [37], and some recent work from our center has found this number to increase progressively over time in patients undergoing DNHD [38]. The effects these changes have on survival await further evaluation in larger prospective studies.

Quality of life

Dialysis is associated with substantial loss of QOL. The London study collected detailed QOL information using the generic Medical Outcomes Survey Short Form (SF-36) and the global Health Utilities Index (HUI), both of which have been validated for use in the dialysis patient population. Improvements in many symptoms were attributable to better fluid management, including less cramping on dialysis, fewer headaches, less symptomatic hypotension, and less dyspnea [39]. HUI results showed that quotidian dialysis patients maintained functionality throughout the study period, while control patients manifested a significant loss. Indeed, 40% of patients unemployed while on conventional dialysis were able to return to full-time employment after switching to quotidian dialysis. Depression scores have been shown to improve in other quotidian hemodialysis studies [40].

Various other methods including the standard gamble, the time trade-off technique, and measurement of time to recovery after a dialysis session have also been evaluated, all favoring quotidian over conventional dialysis [39,41,42]. Even in patients with high levels of comorbidity, Ting et al found that SDHD resulted in improvements in a number of QOL parameters, including sexual function, sleep, physical functioning, and general health [13]. Perhaps the most striking observation is that quotidian dialysis patients freely choose to carry out their treatments on a near-daily basis despite the cumbersome and time-consuming nature of their therapy, the medicalization of their households, and the inconvenience to their families. The potential for social and vocational rehabilitation alone are compelling arguments in favor of the widespread use of quotidian dialysis.

Metabolic bone disease, calcium, and phosphate

The management of metabolic bone disease in ESRD is complex and requires frequent manipulation of drug regimens and diet. By virtue of its increased overall treatment time, DNHD, in particular, substantially ameliorates phosphate control [43]. Significant phosphate depletion has been observed despite liberalization of dietary phosphate intake and elimination of phosphate binders. This has required phosphate supplementation in the dialysate in order to prevent osteomalacia and symptomatic hypophosphatemia.

In DNHD, calcium depletion is also a potential problem. Using a standard bath calcium concentration of 1.25 mmol/L, the London group noticed progressive rises in intact parathyroid hormone (PTH) levels that were refractory to large doses of vitamin D analog therapy [44]. These patients had been taken off all calcium-based phosphate binders because of normalization of serum phosphate levels. This hyperparathyroidism was readily reversed by increasing the dialysate calcium concentration to 1.75 mmol/L. Subsequent mass balance studies showed that DNHD resulted in a net calcium loss of 2 mmol/hour when a bath concentration of 1.25 mmol/L was used, while a gain of 3.7 mmol/hour was observed with a 1.75 mmol/L bath concentration. The combination of a standard (low) dialysate calcium concentration with loss of oral calcium intake due to the elimination of calcium carbonate-based phosphate binders resulted in significant calcium depletion and hyperparathyroidism. A study from HRRH found that an average bath calcium concentration of 1.6 mmol/L helped to maintain or improve the bone mass of patients, as measured yearly using dual-energy X-ray absorptiometry densitometry, and suppressed PTH to the normal range. This may have been the cause of the low bone turnover diagnosed by bone-marrow biopsy in nine of 15 patients. This suggests that the calcium level in the dialysate may need to be adjusted according to the needs of the patient. This was achieved at HRRH through the addition of powdered calcium chloride by the patient at specifically prescribed amounts.

With a substantial reduction in phosphate levels achieved with DNHD, and to a lesser extent with SDHD, there is a net reduction in the calcium/phosphorus product. This parameter is associated with metastatic calcification and increased mortality. Interestingly,

DNHD has been reported to cause dissolution of extraosseous calcification [45]. Overall, it appears that the net effect of quotidian dialysis on calcium and phosphate metabolism is favorable, provided that appropriate changes are made to the dialysate composition and patients are followed for the development of hyperparathyroidism.

Sleep disturbances

Sleep abnormalities remain highly prevalent in the ESRD population and are associated with poor QOL and increased mortality [46,47]. Baseline sleep studies were performed in 14 subjects in the Toronto Study [48]. In the eight patients with obstructive sleep apnea, conversion to DNHD normalized the frequency of apnea/hypopnea episodes from 46 ± 19 to 9 ± 9 per hour ($p < 0.006$), and resulted in normalized oxygen saturation during sleep. Despite these changes, another study failed to show any reduction in daytime sleepiness with DNHD as measured by the multiple sleep latency test [49]. The effect of SDHD on sleep apnea is unknown.

Uremia is associated with impaired autonomic regulation. The impact of DNHD on nocturnal cardiac autonomic outflow has also recently been evaluated by our group. We performed heart rate variability analysis during stage 2 sleep in nine ESRD patients on conventional hemodialysis and 6 to 15 months after conversion to DNHD. DNHD was associated with a reduced duration of nocturnal hypoxemia and restored the normal balance between sympathetic and parasympathetic modulation of heart rate [50].

Economic Issues in Quotidian Dialysis

The financial implications of daily dialytic therapy probably vary significantly when comparing home with in-center treatment. Today, most available data come from home daily dialysis studies.

Potential sources of cost savings

Since home dialysis relies on self administration of therapy, there is an obvious and substantial reduction in nursing and technical support staff costs. Reductions in antihypertensive medications, EPO, phosphate binders, hospitalizations, and vascular access interventions also hold significant potential for cost reduction either to the dialysis program itself and/or to the health care system at large.

Sources of increased expenditure

The main upfront costs for home quotidian dialysis include dialysis machine purchase and installation as well as installation of water supply and purification systems. Moreover, it includes the expense of training the patient. Thereafter, longitudinal costs in disposable materials, including dialysate, dialysis membranes and tubing, increase in proportion to the frequency of treatment.

Balancing costs and savings

The most detailed economic analyses to date in the area of home quotidian dialysis come from the London (SDHD and DNHD vs conventional) and HRRH (DNHD vs conventional) programs. A prospective descriptive economic analysis by McFarlane et al (HRRH) showed that home DNHD was associated with a CAN$13,000/patient/year reduction in total health care costs when compared with conventional in-center hemodialysis [51]. In the London experience, for any given year of follow-up, no significant differences between SDHD, DNHD, and conventional in-center dialysis were noted [41]. However, when total treatment costs for the first year on quotidian dialysis were compared with the previous year's costs on conventional therapy, switching to SDHD and DNHD resulted in a US$7,171 and US$12,782 per-patient cost saving, respectively. Remaining on conventional in-center dialysis, however, resulted in a US$2,247 increase in total costs for 1 year. This analysis did not take into account the 40% of patients who were able to return to full-time employment after switching to quotidian dialysis and the benefit to society that this confers.

The situation for in-center dialysis is more complicated. Increasing the total volume of dialysis treatments in a given center can place significant strains on system resources, including personnel and disposable materials. It is hoped, but not yet proven, that any additional costs incurred with daily in-center dialysis would be offset either financially by reductions in hospitalizations, consultations, investigations, and other treatments, or otherwise by improving QOL and other outcomes while accepting increased costs. This has been shown in a retrospective study by Mohr et al, but prospective studies are needed [52].

Unfortunately, dialysis programs in most countries often operate near the maximum cost per quality-adjusted life-year gained that society is prepared to pay. Furthermore, financial data obtained from one practice setting may not be generalizable to another. Thus, programs, or at least countries with varying health care funding mechanisms, may benefit from locally performing small economic feasibility studies prior to embarking on large-scale implementation of in-center quotidian dialysis programs.

Future Directions in Quotidian Dialysis

As can be seen from the preceding discussion, quotidian dialysis improves numerous intermediate outcomes that

are themselves associated with increased survival in the dialysis population. It therefore seems reasonable to expect that quotidian dialysis will indeed be shown to reduce mortality in patients who require dialysis. To date, however, quotidian dialysis studies have been small and, thus, underpowered to detect survival differences, but larger-scale North-American-based studies are currently underway and may ultimately resolve this issue. These include a prospective, randomized, controlled trial comparing in-center SDHD with conventional hemodialysis, and another comparing home-DNHD with in-center conventional hemodialysis. Although these are not necessarily survival studies per se, they may serve as feasibility studies to determine whether or not a larger-scale survival study is warranted. Additionally, an International Quotidian Dialysis Registry, which will begin collecting data by mid-2004, will be used to collect descriptive data on quotidian dialysis patients worldwide and will provide data for a matched cohort-controlled survival study using conventional dialysis patients listed in other large registries as controls [53]. Both of these are US National Institutes of Health-endorsed initiatives. The Registry is also endorsed by the International Society for Hemodialysis. The results of these studies are eagerly awaited.

Conclusions

SDHD and DNHD are emerging cost-effective treatment modalities that are associated with improvements in many important clinical outcomes including cardiovascular health, nutrition, and QOL. Although many advocates for quotidian dialysis believe that existing data should justify making these treatments widely available through appropriate funding mechanisms, it is unlikely that policies will change on a large scale until improvements in hard outcomes are established. At present, ongoing research initiatives strive to delineate a clear role for these promising therapies. In the interim, it is hoped that dialysis programs with sufficient interest and resources will make these treatments available to patients who may benefit from them the most. In the next decade, quotidian dialysis will probably find its appropriate place in the dialysis modality mix, and may represent a great advancement in the ongoing endeavor to improve outcomes for patients who require dialysis.

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